



DESIGNER SOIL

Classroom Activity for Dig It! Soil Exhibition

Overview

In this activity, participants learn that soil is made of many different components by exploring and identifying three different types of soils (sand, silt & clay). After exploring the soils participants can select a seed, design a soil that the seed will best thrive in, and bring their plant home to watch it grow.

Audience

This activity can be implemented in a classroom, exhibit, or outreach setting and is appropriate for all ages. This activity could easily be transformed into a 30-minute classroom lesson depending on the amount of information provided to the participants and time spent exploring and designing the soils. No prior knowledge or experience with soils is necessary.

Activity Length

- Outreach: 5-10 minutes
- Classroom: 10-30 minutes

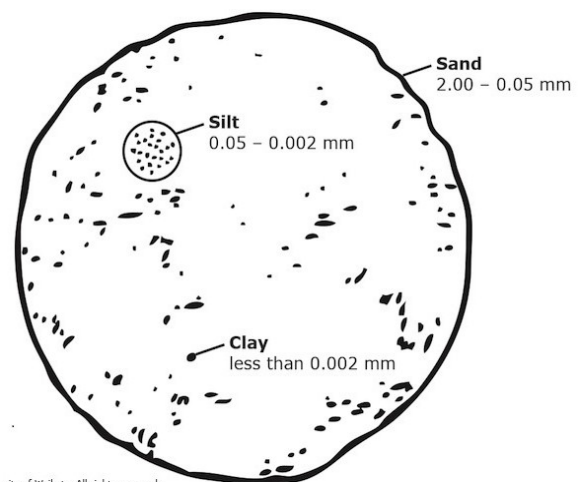
Background

There are three basic types of soil: sand, silt and clay. But, most soils are composed of a combination of the different types. How they mix will determine the texture of the soil, or, in other words, how the soil looks and feels.

Sand is fairly coarse and loose so water is able to drain through it easily. While this is good for drainage, it is not good for growing plants because sandy soil will not hold water or nutrients.

Silt is another type of soil. Silt can be thought of as fine sand, and it will hold water better than sand. If you were to hold a handful of dry silt in your hand, it would feel almost like flour. If you were to add water to the silt in your hand, it would do a fair job of holding the water and feels slick and smooth.

Clay is fine-grained soil. Its particles are even smaller than silt so there is very little space between the fine grains of air or water to circulate. Therefore, clay does not drain well or provide space for plant



University of Waikato. All rights reserved.

roots to flourish. When moisture is added to clay it can be molded into shapes such as pots, bowls or building bricks.

Learning Objectives

1. Learners will understand that soil is complex in its composition and appearance--it's not just dirt.
2. Learners will develop more positive feelings towards soil and its role in supporting biodiversity.
3. Learners will practice making observations to classify different soils presented in the activity and in their neighborhood.

Materials & Cost

Materials

- 2 large tables
- Towels (for cleaning off stations)
- Large whiteboard, eraser, markers for recording thoughts and observations
- Station 1: Soil Investigation
 - 4 large storage bins of locally-obtained soils: sandy, silty, clay, compost
 - Hand lenses
 - Soil Jar Test
 - Instruction paper for continuing their investigation at home
 - At least 2 settled Soil Jar Tests (for display)
 - Signage:
 - Soil Consistency key
 - Soil Color key
 - 2 clear sign stands
 - Flip-up labels for soil bins (laminated)
 - Optional: Gardening gloves or disposable gloves
- Station 2: Designer Soil Station
 - Biodegradable pots
 - Seeds of soil-appropriate plants
 - Biodegradable spoons
 - Soil Triangle poster
 - Stickers with instructions for seed care
 - 4 medium-sized storage containers for holding 3 soil types + compost
 - Signage:
 - Designer Soil instruction sheet
 - 1 clear sign stand
 - Labels for each bin (laminated)

Shopping List

- Large folding tables
- Large containers for storing soil
- Medium containers
- Spoons
- Biodegradable pots
- Clear sign holders
- Hand lenses
- 2 plastic jars
- Watering instruction stickers
- Large whiteboard
- Whiteboard markers
- Soils
 - Silt
 - Sand
 - Clay
 - Compost
- Seeds
 - Corn
 - CA poppies
 - Swiss chard
 - Green beans
 - Sweet peas
 - Marigolds

Cost

Table 1 - Budget (one-time purchases)

Item	Price (individual item)	Total Cost
Large soil storage containers (4)	\$25.00	\$100.00
Medium soil storage containers (4)	\$5.00	\$20.00
Clear sign holders (3)	\$14.00	\$14.00
6ft. folding tables (2)	\$64.00	\$128.00
Large whiteboard	\$151.00	\$151.00
Hand lenses (10)	\$1.00	\$10.00
Mason jars (6)	\$2.67	\$16.00
TOTAL	-	\$288.00

The estimated cost of consumable items per learner is \$0.65.

Table 2 - Budget (continuing purchases)

Item	Price (individual item)	Total cost	Cost Per Learner
Biodegradable spoons (100)	\$0.09	\$9.00	\$0.01
Biodegradable pots (50)	\$0.06	\$3.00	\$0.06
Watering instruction stickers (128)	\$0.04	\$4.67	\$0.04
Whiteboard markers (2 sets)	\$6.88	\$13.76	\$0.50
Soil Particles	-	-	\$0.02
-Sand (1.5 cu. ft./bag)	\$12.99	\$25.00	-
-Silt (1 cu. ft./bag)	\$10.99	\$22.00	-
-Clay (2 pound order)	\$9.00	\$27.00	-
-Compost (2 cu. ft/bag)	\$4.00	\$8.00	-
Seeds	-	-	\$0.02
-Corn (500 seeds)	\$0.01	\$5.00	-
-California Poppies (5000 seeds)	\$0.01	\$7.00	-
-Green Beans (450 seeds)	\$0.04	\$18.00	-
-Swiss Chard (600 seeds)	\$0.05	\$30.00	-
-Sweet Peas (600 seeds)	\$0.02	\$12.00	-
-Marigolds (1000 seeds)	\$0.01	\$16.00	-
TOTAL	-	\$186.67	\$0.65

Activity Details

In this activity, participants will classify the different particles that make up the soils (sand, silt or clay). They will investigate these particles through hands-on exploration and focus on differentiating between the color and texture (consistency) of each type. Staff will facilitate their learning experience by probing for deeper understanding and connecting their learning to the scientific tools and mindsets that researchers, geologists, and agricultural professionals use in the field. By utilizing the Soil Triangle, Soil Jar Tests, and other investigative tools, participants will engage in authentic scientific activities and use evidence to draw conclusions about soil.

Participants will be encouraged to continue their soil investigation by creating their own Soil Jar Test at home with the soil in their community, as well as planting a seed in a soil they design to bring home and watch grow!

Setup (See Supplement 1)

Station 1: Soil Investigation:

- **Day of or day before:** scoop soil from different sources into a clear jar and shake thoroughly. Sand will settle at the bottom, silt in the middle, and clay fully at the top after 24 hours.
- Put out 3 storage bins containing the three soil types (clay, silt, sand). Attach the foldable labels (See Supplemental 8) to the front of each container, facing the guests.

- Set out signs and placards on the table in front of the bins. These signs are the techniques that prompt guests to figure out more about the soil in front of them (consistency and color) (See Supplements 3 and 4).
- Put out soil test jars as at-home investigation tools (continued learning).
- Print out soil jar test handout and cut in half. Set out a stack for guests. (See Supplement 2).
- Distribute hand lenses on the table for guests to explore.

Station 2: Designer Soil:

- Set out large modified soil triangle poster (See Supplement 6).
- Set out designer soil seed signage (See Supplement 5).
- Lay out materials for guests to take home an optional personalized soil and seed (See Supplement 9).
- Have 1 storage bin handy for refilling compost container on the table. Refill other 3 medium containers as necessary from the bins at Station 1.
- Attach labels to each medium-sized soil container (See Supplement 8).
- Prop up whiteboard and markers for participants to respond to prompts.

Detailed Activity Guide

When guests join the table, they will come with a diverse background and comfort level about soil. Some may garden every weekend and others may be averse to touching soil. This interactive is intended to help learners explore what makes up soil and how it is connected to the greens they see and the food they eat.

Introduction

Be friendly and invite your participants to learn more about soil. You can ask them what they already know about soil and gauge their comfort level. These open-ended questions can be used in a classroom setting with an entire class or small groups. Example questions to start the conversation:

- ***What do you know about soil?***
- ***Where do you think soil comes from?***
- ***How does soil affect our everyday lives?***
- ***What can we/want to learn from soil?***

Station 1: Soil Investigations

At Station 1, guests are challenged to figure out what kind of soil they are touching (silt, clay, or sand). They can figuratively and literally dig into the bins, squeezing, touching, exploring, and talking to learn more. You can listen in on their conversations and act as a resource to guide their investigation.

Encourage visitors to use the Soil Consistency and Soil Color keys on the tables, in addition to hand lenses or other tools, to gather evidence and come to a conclusion. The more social the station, the more invested visitors will be. Check in with bystanders watching participants and ask for their thoughts.

Once visitors feel comfortable with their conclusions, they can flip the sign at the front of the bins to check their reasoning. Probing questions/comments may include:

- ***What does the soil feel like?***
- ***How are they the same? How are they different?***
- ***Tell me more about that.***
- ***Does anyone agree or disagree? Why?***
- ***Was anything about this challenge surprising or difficult?***
- ***How did you come to those conclusions?***
- ***What is the soil telling you?***
- ***Does this look like soil you've experienced before?***

The Soil Test Jars can be used as a tool to support your interactions. Guests are encouraged to try this activity at home to test what soil is in their community. All they need to get started is a clear container, tap water, and a couple scoops of soil. They can grab a handout with instructions on how to continue this investigation at home. Participants can be encouraged to share the location of their sample and their findings with CSULB Science Center social media--this can be valuable data for mapping out soils of California, beginning a community science project, and letting guests manipulate primary scientific data.

Station 2: Designer Soil

This station expands more on the applications of their soil identification and considers soil characteristics through the lens of plant life. Scientists, farmers, architects, engineers, climate scientists, and historians use the Soil Triangle to help identify exactly what kind of soil they are examining. This has consequences for water drainage, climate events, temperature control, and nutrient concentrations.

After picking which plant they would like to grow from the Designer Soil Sign, learners follow the “recipe” for creating the plant’s ideal soil. Walk them through how to use the Soil Triangle as they cultivate the perfect foundation for their chosen crop. They can trace a finger horizontally, diagonally up, and diagonally down to identify their soil type. The Soil Triangle is split into percentages of clay, silt, and sand particles in a sample that will all add up to 10 spoonfuls (100%) in their biodegradable pot. Be sure to have them add 1 spoonful of compost to help their seed grow (adds up to 11 spoonfuls total).

You can continue building on what they discovered at Station 1 with these potential prompts or try out your own open-ended questions:

- ***What do you notice about your designer soil?***
- ***Does your designer soil feel like the soils you felt earlier? Why or why not?***
- ***How does your soil affect your plant? (i.e. clay is sticky and densely packed, roots will likely be shallow, be scant with watering)***

- ***What kind of plants do you see in your community? What can they tell you about soil near you?***

After receiving their seed and instruction sticker, you can direct them to the whiteboard to record their thoughts if they choose to. Feel free to use one question throughout the day or alternate questions. What guests write can be valuable information in the future for informing how successful this activity is, what guests are learning, and how it can be modified.

Sample questions include:

- ***How do you feel about soil?***
- ***What did you like about feeling soil?***
- ***What did you learn about soil?***
- ***What did you discover about soil?***

Piloting Considerations

Due to the COVID-19 pandemic, we were unable to pilot our activities in the field or conduct evaluations on our program. There are a few things to keep in mind when this program is run either at an outreach event or in a classroom setting:

- **The flow of participants at the table.** Participants don't necessarily have to or want to take part in both portions of the activity. What does this mean for the general flow of people when this activity is in full swing? How much time do people spend at the tables overall?
- **Soil bags are heavy.** Consider this factor when moving them at the activity, purchasing from nurseries/soil supplies, and storing supplies at the Science Learning Center.
- **Soil types.** Are guests able to identify differences between the three soil types?
- **Placement of supplies.** Some items may need to be rearranged after seeing how they impact guest interpretation and use of supplies. Particular attention should be paid to the large bins filled with soil. Potentially experiment with the best location for them where they maximize engagement without stagnating flow.
- **Interpretative messaging.** We suggest keeping a journal or other casual record of guest interactions when this activity is piloted. Some things to keep in mind:
 - Do some questions engage guests more than others? Does this change with different demographics?
 - What are people recording on the whiteboard prompter? Do their experiences match up with the stated learning objectives? Taking pictures of the board before erasing can help with informal data collection.
 - How successful do volunteers/facilitators feel when running the program?

- What do guests seem to be interested in after touching (or watching others touch) the soil? What are their reactions?
- **Seed/soil viability.** We suggest testing seed germination in the SLC under different conditions. Does the seed germination occur easily at home? Do the soil recipes that we laid out work the way we imagine they will? Adjust watering/light instructions if necessary.

Rationale

This outreach activity encourages participants to engage directly with soils in order to explore their physical makeup. To accomplish this, we decided that having the “real thing” was an important aspect in achieving our objectives. In addition to tactile components (the soil) we chose to include a number of visuals in order to encourage deeper discussions and provide multiple modes of engagement for all learner types.

When creating the signage, we referred to recommendations from the Exploratorium’s EDGE guide for science exhibit design. Our signs feature real objects and images of people; our design allows for simultaneous participation from multiple people, is viewable from a distance, has multiple sides, and features familiar objects (spoons, magnifying glasses, soil).

The ideas for our program were developed from the research and curriculum conducted by CSULB’s Drs. Whitcraft and Stevens. The laboratory assignments that they give to students feature investigations about various physical characteristics of soil and implications of those aspects on the living worlds they support. Soil structure, pH, and smell were fairly abstract concepts to convey in a quicker outreach program and we left those out of our design.

The Soil Triangle came up in both of their presentations and after consulting local nurseries, it became apparent that it was a basic soil concept that we should include as well. Incorporating the seed growing component and the soil jar test were tools that learners could use to potentially foster interest about the soils around them, and support our Nature of Science goals.

Nature of Science Tenets

Nature of Science tenets were intentionally factored into this program. The first table centers around a social investigation of the characteristics of soil. Guests use their observations to inform their decision about which soil type they are looking at. These observations become evidence that can be used to support or refute their hypotheses. Guests also practice using inferences as well as inductive/deductive reasoning when making connections between the soil color/consistency keys, their prior knowledge, and the information they learn from facilitators.

At the second table, learners create a custom soil to continue their investigation about soil at home. This process shows guests that scientific research is not reserved to the scientific method--investigations can take the form of data sifting or even serendipity.

Six Strands of Science Learning

We also took into consideration the 6 strands of science learning with the ultimate goal of encouraging learners toward strand 4- reflecting on science but with the expectation that most will only reach strand 1- sparking interest and excitement. To encourage learners to reach strand 4 we first incorporated

interesting and exciting aspects such as bins of soil to put their hands in and seeds to plant, take home and watch grow.

To encourage engagement in strands 2 and 3- understanding scientific concepts and knowledge and engaging in scientific reasoning, we incorporated signage and educators to have informational and meaningful scientific conversations with the learners. Additionally, the background information provided to the educator was developed in a simple and concise manner to ensure educators who do not have a background in soils will still have a strong understanding of the topic.

Finally to reach strand 4, a whiteboard is used as a place for learners to reflect on the things they discovered, learned or to present questions they still have. The activity has the ability to build upon itself but is entirely up to the learner's discretion and interest.

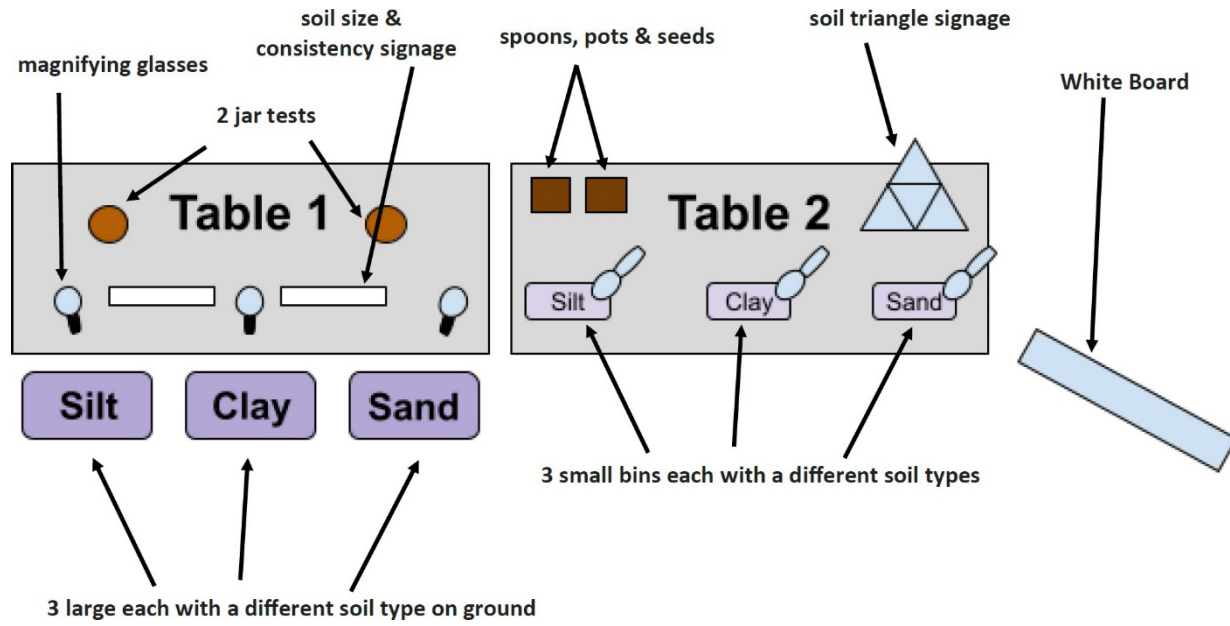
Activity Resources

The following resources are available at the end of this document.

- Supplement 1: Set Up
- Supplement 2: Jar Test Handout
- Supplement 3: Soil Consistency
- Supplement 4: Soil Color
- Supplement 5: Soil Mixture Percent
- Supplement 6: Soil Triangle
- Supplement 7: Lesson Summary for Volunteers
- Supplement 8: Soil Bin
- Supplement 9: Plant Care Stickers

Supplement 1:

Set Up



Supplement 2:

Jar Test Handout

The Glass Jar Soil Test

What you Will Need

- 1: 1 tsp dish detergent
- 2: A magic marker
- 3: 1 cup of soil
- 4: A jar with a lid
- 5: A ruler



$\% \text{ Clay} = \text{Clay} / \text{Total Dirt}$
 $\% \text{ Silt} = \text{Silt} / \text{Total Dirt}$
 $\% \text{ Sand} = \text{Sand} / \text{Total Dirt}$

Follow these steps

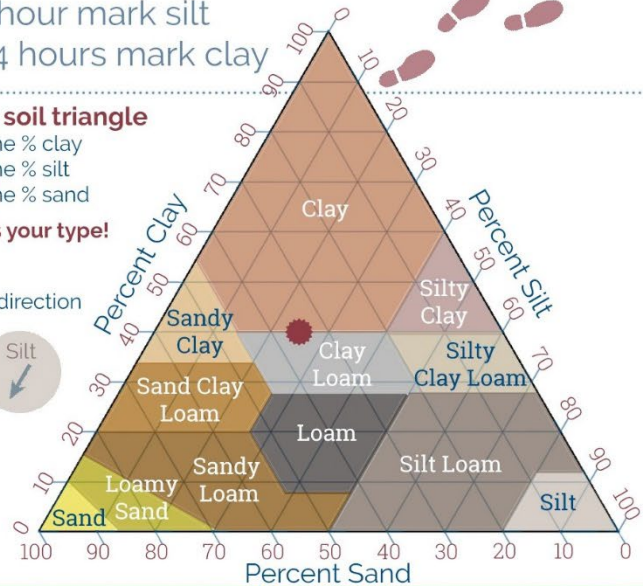
- 1: Add soil to the jar
- 2: Add detergent & fill jar with water
- 3: Replace lid & shake vigorously for 3 min
- 4: After about 1-2 minutes mark sand
- 5: After 1 hour mark silt
- 6: After 24 hours mark clay

How to use the soil triangle

Trace the line for the % clay
Trace the line for the % silt
Trace the line for the % sand

The intersection is your type!

Trace the lines this direction



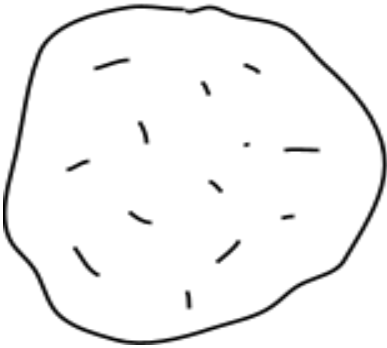

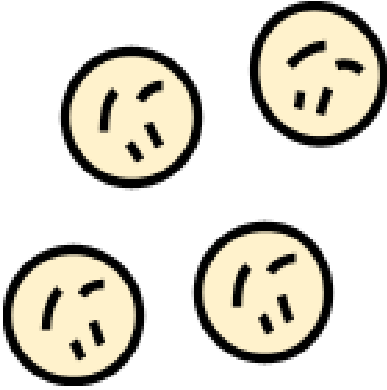

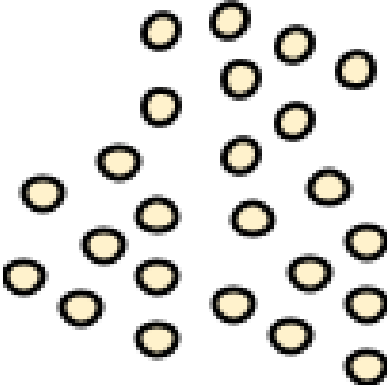

Supplement 3:

Soil Consistency

Touch, feel, investigate the soil!

What happens after you squeeze it or rub it between your fingers?

How are they different or similar?

<p>Sand “Gritty” Falls apart easily Individual grains</p>	<p>2.0 - 0.05 mm</p>  <p>A diagram of a single, irregularly shaped sand grain with several short, straight lines inside representing its internal structure.</p>	 <p>A close-up photograph of a hand holding a small amount of dark sand between the fingers.</p>
<p>Silt “Floury” Feels soft or smooth Smaller grains</p>	 <p>A diagram showing four circular silt grains, each with two short, curved lines inside representing its internal structure.</p>	 <p>A photograph of a hand holding a mound of fine, light-brown silt soil.</p>
<p>Clay “Sticky” Forms a clump Tiny grains</p>	 <p>A diagram showing numerous tiny, circular clay grains arranged in a clumpy pattern.</p>	 <p>A photograph of hands kneading a lump of dark, sticky clay soil.</p>









Supplement 4:

Soil Color

Soil is a kaleidoscope of color.

What can it tell us?

What causes the color?

Moisture	Organic Matter	Mineral Matter	Iron Abundance
 <p><i>drier</i></p>	 <p><i>high concentration</i></p>	 <p><i>white chunks = calcium carbonate</i></p>	 <p><i>lots of iron, well-draining</i></p>
 <p><i>wetter</i></p>	 <p><i>low concentration</i></p>	 <p><i>black striping = manganese</i></p>	 <p><i>low iron, poor-draining</i></p>




Color tells us the history of agriculture, water movement, and timeline of soil formation.

We categorize it by **brightness**, **lightness**, and **color**.

Supplement 5:

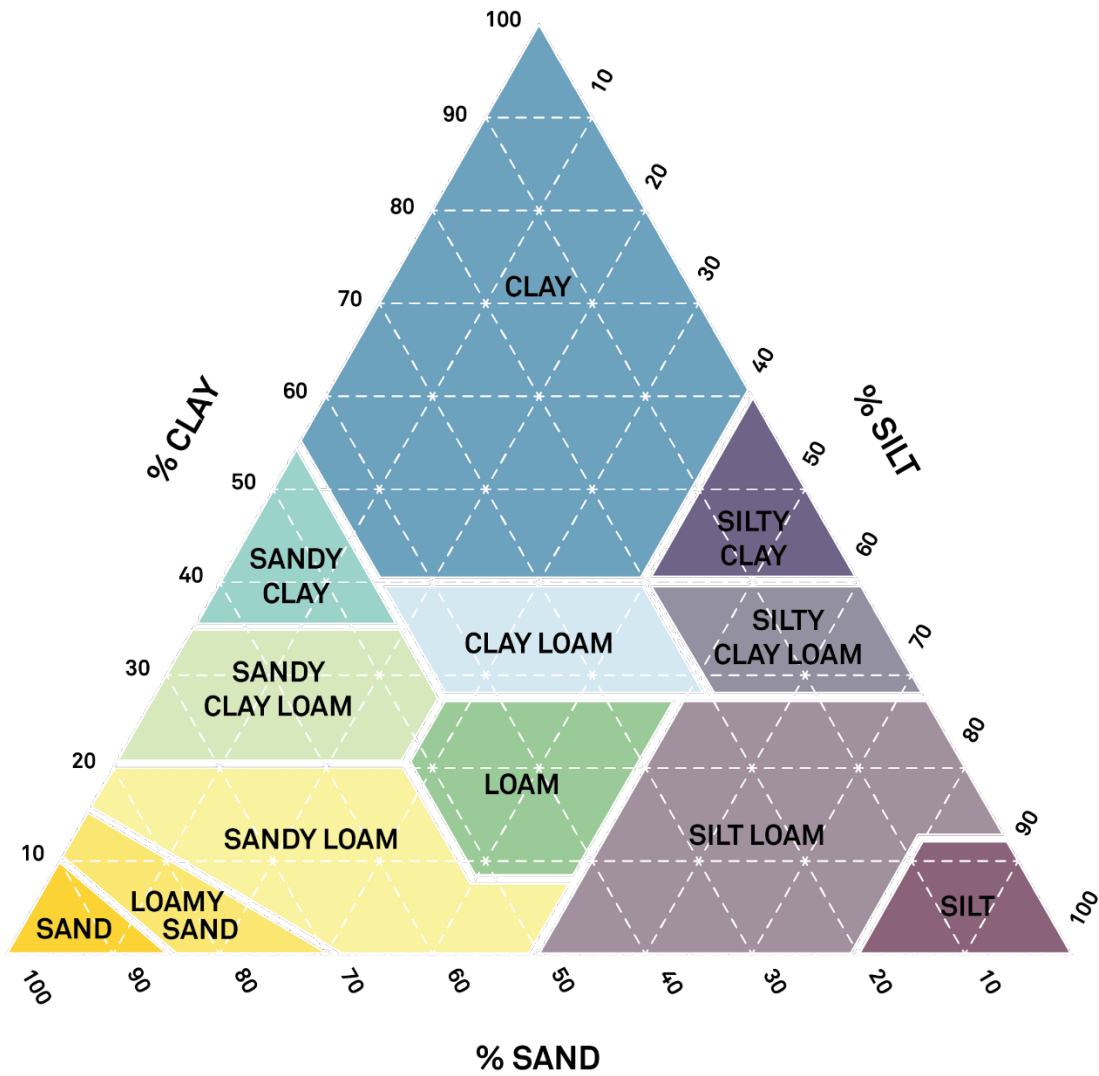
Soil Mixture Percent

What type of designer soil does your plant need?

<p>Sandy Loam</p>	<p>Corn or CA Poppies</p> <ul style="list-style-type: none"> • 6 Spoonfuls of Sand • 3 Spoonfuls of Silt • 1 Spoonful of Clay • 1 Spoonful of Compost 	
<p>Silty Loam</p>	<p>Swiss Chard or Green Beans</p> <ul style="list-style-type: none"> • 2 Spoonfuls of Sand • 6 Spoonfuls of Silt • 2 Spoonfuls of Clay • 1 Spoonful of Compost 	
<p>Clay Loam</p>	<p>Sweet Peas or Marigolds</p> <ul style="list-style-type: none"> • 4 Spoonfuls of Sand • 3 Spoonfuls of Silt • 3 Spoonfuls of Clay • 1 Spoonful of Compost 	

Supplement 6:

Soil Triangle



Source: <https://www.metergroup.com/environment/articles/which-soil-sensor-is-perfect-for-you/>

Supplement 7:

Lesson Summary for Volunteers

Station 1: Soil Investigations


- a. Soil at the event
 - i. Guests approach the table and squeeze the soil in each bin!
 - ii. Using the two signs (consistency and color) and help from the staff/volunteers, participants will determine if the soil in each bin is silt, clay, or sand.
 - iii. Once they feel confident with their answers, they can flip the signs to check if they were correct.
- b. Soil at home
 - i. Give handout on how to test the soil around their neighborhood.
 - ii. Show the jars as an example of how they can test their soil at home, continuing investigation in their own communities.

Station 2: Designer Soil

- c. Have participants pick a seed to plant and ask them to “design a soil” for their seed. Staff/volunteers share with guests that plants need different types of soil to thrive. For example: corn grows best in sandy soil.
 - i. Place a sticker for growth directions on a biodegradable cup and give to the participant
 - ii. Participants will use the soil triangle poster to figure out how many spoonfuls of soil to put into their cup based on their seed type.
 - iii. Guests will use the spoons or their fingers to thoroughly mix their designer soil.
 - iv. Have guests add one spoonful of compost to kickstart their seed.
- d. Before participants leave, invite them to share their experience on the whiteboard.

Supplemental 8:

Soil Bin



Touch to figure out what type of soil this is




Touch to figure out what type of soil this is

CLAY SOIL



SANDY SOIL





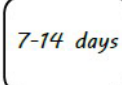


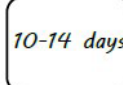
Touch to figure out what type of soil this is



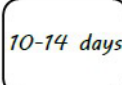


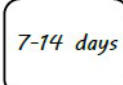
SILTY SOIL



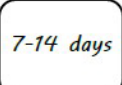


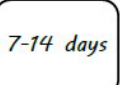


Supplement 9:

Plant Care Stickers

<p>Swiss Chard</p> <p>Full Sun  Sol Completo</p> <p>Every Other Day  Cualquier Otro Día</p> <p>Germination  7-14 days Germinación</p>			<p>Green Beans</p> <p>Full Sun  Sol Completo</p> <p>Every Other Day  Cualquier Otro Día</p> <p>Germination  10-14 days Germinación</p>		
--	--	--	--	--	--

<p>California Poppy</p> <p>Full Sun  Sol Completo</p> <p>Once a Week  Una Vez Cada Semana</p> <p>Germination  10-14 days Germinación</p>			<p>Corn</p> <p>Full Sun  Sol Completo</p> <p>Daily  Diariamente</p> <p>Germination  7-14 days Germinación</p>		
---	--	--	---	--	--

<p>Sweet Peas</p> <p>Full Sun  Sol Completo</p> <p>Every Other Day  Cualquier Otro Día</p> <p>Germination  7-14 days Germinación</p>			<p>Marigolds</p> <p>Full Sun  Sol Completo</p> <p>Daily  Diariamente</p> <p>Germination  7-14 days Germinación</p>		
---	--	--	--	--	--